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13. ABSTRACT (*Maximum 200 words*)

Purpose: To study the effect of menstrual phase on pulmonary function and exercise performance in young women.
Methods: We prospectively evaluated differences in pulmonary function, exercise capacity and airway hypperreactivity at two times during the menstrual cycle, the early follicular phase (day 3) and the mid-luteal phase (day 23).
Results: Nineteen healthy non-pregnant servicewomen with a mean age of this group was 23.7 years, ± 1.9 years (mean ± SD) were studied. The mean FEV1 percent predicted was 94.1% ± 9.9% and the mean FVC percent predicted was 97.5% ± 9.0%. Using the paired t-test, we found no significant differences between days 3 and 23 in:

Outcome	Difference(mean)	SD	95%CI for diference
FEV1(L)	-0.021	0.17	-0.10 to 0.06
FVC(L)	-0.005	0.17	-0.09 to 0.08
PIP(cm H20)	+2.21	10.83	-3.01 to 7.43
DLCO (Hgb corrected) (ml/min/mmHg)	-0.32	2.37	-1.64 to 0.99
Vemax(L/min)	+2.94	11.87	-2.78 to 8.66
Exercise time(sec)	+6.79	22.68	-4.14 to 17.72
VO2@ AT(ml/min)	-4.26	123.09	-63.59 to 55.06
VO2max(ml/min)	+25.74	141.12	-42.28 to 93.75
DFEV1[L]	+0.57	7.19	-3.02 to 4.13
DFVC[L]	+0.22	5.77	-2.65 to 3.09

Conclusions: We conclude that there are no significant differences in pulmonary function, exercise capacity or airway hyperreactivity between early follicular and mid-luteal phases of the menstrual cycle in this group of servicewomen.

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Oleh W. Hnatiuk, MAJ, MC 29 April 96

PI - Signature Date

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INTRODUCTION:

Results of the 1988 Active Army Physical Fitness Survey[1] revealed that a significantly higher percentage of female soldiers between the ages of 17 and 26 failed the 2-mile-run portion of the Army Physical Fitness Test (APFT), compared to male soldiers of the same age. Successful completion of the APFT is critical to retention and promotion and presumably to combat readiness as well. In their study, O'Connor and Bahrke[1] note that "a large and unacceptable percentage of soldiers under the age of 35 may not possess the cardiovascular or muscle strength and endurance necessary to withstand exposure to prolonged combat." However, if the APFT is given to female soldiers during a phase of their menstrual cycle when their ability to perform maximally is reduced, this critical test would not be an accurate reflection of true maximal performance level.

There have been few studies about the effects of menstrual phase on pulmonary function and exercise performance published over the past 28 years.[2-5] The studies that have been published were performed using a limited number of subjects and revealed conflicting results. In 1981, Schoene and colleagues[2] reported a significant decrease in exercise performance during the luteal phase of the menstrual cycle in their six controls (women with normal menstrual cycles). These authors also demonstrated increased ventilatory drive and exercise ventilation during the luteal phase. In 1989, Nicklas and colleagues[3] reported their observations of exercise response and muscle substrate responses in 6 eumenorrheic females. They exercised their subjects at 70% of predicted VO2max until exhaustion and found that exercise duration and glycogen repletion were greater at the mid-luteal phase, compared to the mid-follicular phase. These authors concluded that "...athletic performance may be affected by the phases of the menstrual cycle."

Chen and Tang[4] investigated the effect of menstrual cycle on respiratory muscle function in 30 healthy adult women. Inspiratory muscle endurance (product of pressure load and sustained time; pressure-time index) was found to be greater in the mid-luteal phase, compared to the follicular phase. They concluded that "inspiratory muscle endurance is affected by the menstrual cycle". Interestingly, in that same study, no difference in resting pulmonary function was noted. De Souza and colleagues[5] studied exercise performance in 8 eumenorrheic and 8 amenorrheic female runners. They found that oxygen uptake, minute ventilation, ratings of perceived exertion and time to fatigue were not affected by the phase of the menstrual cycle. Because of the small number of subjects involved in these studies, we believe there is inconclusive evidence to determine whether menstrual cycle phase affects pulmonary function and exercise performance. This study was designed to definitively determine if different phases of the menstrual cycle are associated with significant differences in pulmonary function, exercise performance and non-specific airway hyperreactivity.

BODY:

Methods:

All female soldiers between the ages of 17 and 26 taking the APFT during 1994 and 1995 at Walter Reed Army Medical Center, Ft. Belvoir and Ft. Meade were eligible for participation. We attempted to study two groups of female soldiers: female soldiers who passed the entire APFT (including the 2-mile-run) and female soldiers who did not pass the 2-mile-run portion of the APFT. Eligible subjects were identified by Master Fitness Trainers (MFT) at each U.S. Army post. These subjects were screened via telephone to identify only those individuals who were eumenorrheic and did not have a history of pulmonary disease.

Testing was performed at two times during the menstrual cycle: the early follicular phase (day 3 of the menstrual cycle) and the mid-luteal phase (day 23 of the menstrual cycle). Cycle phase was documented by serum estradiol and progesterone assays. The order of testing was randomized with respect to menstrual phase (follicular phase first versus luteal phase first) to help control for learning effect in performance of the various pulmonary and exercise tests. During each visit, after completion of a questionnaire, the following resting pulmonary function studies were performed: forced vital capacity (FVC), forced expiratory volume in one second (FEV1), single breath diffusing capacity for carbon monoxide corrected for hemoglobin (DLCO[Hgb corr]) , peak inspiratory pressure (PIP), peak expiratory pressure (PEP), and the respiratory muscle strength (RMS=[PIP + PEP]/2). These were immediately followed by exercise testing.

Exercise testing was performed on a cycle ergometer beginning with unloaded pedaling and progressing with increasing workload of 25 watts each minute to tolerance. A physician and a technician monitored the exercise testing. Continuous monitoring of ECG waveform and oxyhemoglobin saturation was performed. Maximal oxygen consumption (VO2max), oxygen consumption at anaerobic threshold (VO2@AT) and time of exercise (Exercise Time) were recorded. After exercise testing, spirometry was retested within 5 minutes.

If spirometry or clinical evaluation revealed no evidence of bronchospasm (a fall in FEV1 of $\geq$ 10% at 5 minutes post exercise or wheezing), subjects recovered for 2 hours and then underwent bronchoprovocation testing. Forced spirometry was again repeated to obtain a baseline. This was followed by methacholine bronchprovocation. The Rosenthal dosimeter method was used, with gradually increasing doses of methacholine. The best pre-methacholine challenge FEV1 and FVC were compared to the lowest FEV1 and FVC after bronchoprovocation (DFEV1 and DFVC). A $\geq$ 20% fall in FEV1 was considered positive for airway hyperreactivity.

Results:

Over five hundred servicewomen were identified as potential candidates for our study. Participating local Army facilities included Walter Reed Army Medical Center, Walter Reed Army Institute of Research, Fort Belvoir and Fort Meade. Telephone contact was attempted with *all* of these servicewomen. Approximately 50 agreed to participate and met inclusion criteria. PCS, ETS, pregnancy and not wishing to take part were common reasons for non-participation.

Of the approximately 50 servicewomen who initially agreed to participate, 31 servicewomen did not follow through on their initial agreement, for a variety of reasons. The data in this report reflects testing performed on the 19 servicewomen who completed the protocol by 31 December 95. All of these women passed their APFT.

The mean age of the nineteen servicewomen was 23.7 years $\pm$ 1.9 years. (mean $\pm$ S.D.). Nine were taking oral contraceptives. A summary of the mean values for test data is found in Table 1. Using the paired t-test we found no statistically significant differences in the studied variables, between days 3 and 23 of the menstrual cycle. The mean differences between each of the paired variables is displayed in Table 2. The use of contraceptives had no effect on maximal exercise oxygen consumption, exercise time or any test of pulmonary function.

TABLE 1. DAY 3 VS. DAY 23 VARIABLE VALUES

Variable	N	Mean	SD	Range
FEV1(3)[L]	19	3.07	0.39	2.45 - 4.02
FEV1(23)	19	3.09	0.33	2.49 - 3.83
FVC(3)[L]	19	3.66	0.47	2.88 - 4.73
FVC(23)	19	3.66	0.39	2.88 - 4.61
PIP(3)[mm Hg]	19	100.68	25.37	50.00 - 150.00
PIP(23)	19	98.47	23.89	50.00 - 150.00
PEP(3)[mm Hg]	19	147.58	37.57	100.00 - 220.00
PEP(23)	19	152.74	44.20	100.00 - 240.00
RMS(3)	19	124.13	28.53	80.00 - 185.00
RMS(23)	19	125.61	31.61	75.00 - 185.00
DLCO(3)(Hgb corr) [ml/min/mmHg]	15	23.16	3.21	16.57 - 30.32
DLCO(Hgb corr)(23)	15	24.30	3.88	19.87 - 33.48
Vemax(3)[L/min]	19	74.62	20.65	39.10 - 117.80
Vemax(23)	19	71.68	16.56	38.40 - 103.90
Exercise Time(3)[min]	19	462.95	86.12	315.00 - 664.00
ExerciseTime(23)	19	456.16	78.41	325.00 - 636.00
VO2@AT[ml/min](3)	19	871.95	204.77	563.00 - 1405.00
VO2@AT(23)	19	876.21	256.01	550.00 - 1620.00
VO2max(3)[ml/min]	19	1780.21	494.09	1044.00 - 2958.00
VO2max(23)	19	1754.47	462.12	1047.00 - 2795.00
DFEV1(3)[L]	18	6.67	7.52	0.00 - 33.00
DFEV1(23)[L]	18	6.11	4.93	-2.00 - 18.00
DFVC(3)[L]	18	4.22	5.49	-1.00 - 22.00
DFVC(23)[L]	18	4.00	4.51	-3.00 - 14.00

TABLE 2. DIFFERENCES BETWEEN DAY 3 & DAY 23 VARIABLES*

Variable	N	Mean Change	SD	95% CI
FEV1[L]	19	-0.021	0.17	-0.10 to 0.06
FVC[L]	19	-0.005	0.17	-0.09 to 0.08
PIP[mmHg]	19	+2.21	10.83	-3.01 to 7.43
PEP[mmHg]	19	-5.16	26.37	-17.87 to 7.55
RMS	19	-1.47	17.46	-9.89 to 6.94
DLCO(Hgb corr) [ml/min/mmHg]	15	-0.32	2.37	-1.64 to 0.99
Vemax[L/min]	19	+2.94	11.87	-2.78 to 8.66
Exercise Time[min]	19	+6.79	22.68	-4.14 to 17.72
VO2@AT[ml/min]	19	-4.26	123.09	-63.59 to 55.06
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DFVC[L]	18	+0.22	5.77	-2.65 to 3.09

* All p values > 0.05

Discussion:

To date, this is the largest reported study evaluating the effect of menstrual phase on pulmonary function, exercise capacity and non-specific airway hyperreactivity. Our results are similar to those of De Souza[5] and support the premise that the phase of the menstrual cycle has no influence on pulmonary function and exercise capacity. They are also similar to those reported by Pauli and colleagues[6], who found no difference in airway hyperreactivity in a group of 29 healthy women whose mean age was 30.3 years. Therefore, the differences in failure rates on the 2-mile-run between 17 to 26 year old women and men, reported in the 1988 Active Army Physical Fitness Survey[1] , cannot be explained by changes in pulmonary function, exercise capacity or airway hyperreactivity during the servicewomen's menstrual cycle.
Therefore, the APFT can be administered at any time during a servicewoman's menstrual cycle. Failures on the 2-mile-run should not be attributed to phase of the menstrual cycle.

There are several limitations to our study. First, the numbers are not as large as anticipated. Despite screening over a half-thousand women, only 1% agreed to be studied. Although PCS, ETS and pregnancy were common causes of not participating, not wishing to take part was the most common reason. Given the potential impact of finding a difference between days 3 and 23, it is hard to understand why servicewomen did not want to participate. Second, no servicewoman who did not pass the APFT 2-mile-run volunteered to be studied. Unfortunately, it was this group of women in whom we had the most interest. Although it is unlikely that this group is any different than the women in our study or that of De Souza, the small possibility still exists.

CONCLUSIONS:

The phase of the menstrual cycle has no impact on pulmonary function, maximal exercise performance or airway hyperreactivity in this group of servicewomen. The APFT can be administered to servicewomen at any time, without taking into account the phase of the menstrual cycle.

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APPENDIX:

No publications or meeting abstracts are in print at the time of this report. Mr. Angel Sierra is the only person who received pay from this protocol.